ONTARIO

Department of Education

Courses of Study

Grades X, XI and XII

SCIENCE

FOR

VOCATIONAL SCHOOLS

AND

DEPARTMENTS

Issued by Authority of
The Minister of Education

COURSES OF STUDY

For

Grades X, XI, XII

In

Vocational Schools and Departments

SCIENCE

Objectives:

(a) to arouse curiosity in natural objects and phenomena, in order to develop an understanding of the elementary facts of nature;

(b) to teach pupils to observe accurately, to draw logical conclusions from their observations, and to state them clearly and concisely;

(c) to promote rational and healthy living;

(d) to develop a better understanding of the fundamental principles of science as applied to materials, machines, and processes with which pupils come in contact.

To realize these objectives laboratory instruction should be organized to permit pupils to work individually or in small groups. The number of pupils working together will depend, to some extent, on the size of the class, on the equipment available and on the topics studied. For certain topics, where the order in which the experiments are taken is not fixed, the experiments may be carried on simultaneously.

Teachers may find it necessary to set up certain pieces of apparatus as permanent equipment to be in readiness for frequent use. Whenever possible, other equipment used should be assembled by the pupils.

The subject matter of the syllabus has been arranged so that it is closely related to the special courses selected by the pupils. The time suggested for each topic merely indicates the "depth" of treatment.

Some teachers may wish to make greater use of the "unit," or "topical," plan. Such a plan of study follows the growing interests of the pupils and, where the organization of the instruction permits, teachers should not hesitate to rearrange the content of the courses to suit this "unit" plan.

The time allotted to the study of General Science in the vocational schools may not be sufficient to complete all the topics outlined. Teachers should select from these courses the content best suited to the needs of the pupils. Approved methods of teaching should not be sacrificed to cover every detail of the course.

Suitable text-books, as well as books of reference, should be provided in laboratories and in classrooms where science is studied. Illustrative material, such as pamphlets, charts, process diagrams, and sample products should also be procured and filed for ready reference. Pupils should be encouraged to use these books and materials to secure additional information on the topics studied, to understand the practical application of scientific principles and to realize their value.

Grade X

INDUSTRIAL DEPARTMENTS

1. **Heat Units.** (Four periods.)
   (a) Comparison of Fahrenheit and Centigrade scales by means of a graph.
   (b) An experiment to illustrate the meaning of quantity of heat. The distinction between quantity of heat and temperature.
   (c) The calorie and the British thermal unit.
   (d) Experiments to investigate the heat capacities of different substances.
   (e) The importance of the high heat capacity of water in relation to climate.

2. **Heat Transference.** (Four periods.)
   (a) Recall convection currents in water, and the hot-water heating system.
   (b) Experiments to investigate the heat conductivity of various metals.
   (c) An experimental study of commercial refractory materials and insulators.
   (d) Experiments to investigate the radiation of heat from metallic surfaces; its application to the automobile cooling system and to different types of unit-heating equipment.

3. **Thermal Expansion.** (Four periods.)
   (a) Recall the thermal expansion of matter in each of its three states.
   (b) An experiment to show the variable expansion of metals and the thermal distortion of bimetal strips.
   Types of thermostats used for control of automobile cooling systems and manifold heaters, for temperature control in home, school, and office, and for the protection and operation of electrical equipment.
   (c) An experiment to show the thermal expansion of gases. The use of expanding gas to do work.

4. **Change of State.** (Four periods.)
   (a) Experiments to show absorption of heat without change in temperature when ice melts and when water boils.
   (b) The use of ice in refrigerating and of steam in heating.
   (c) An experiment to show cooling by evaporation.
   (d) The principle of artificial refrigeration.

5. **Hygrometry.** (Four periods.)
   (a) Recall presence of water vapour in the air.
   (b) An experiment to determine dew-point.
   (c) Meaning of relative humidity.
   (d) Measurement of the relative humidity of the air in the classroom by means of the wet and dry bulb hygrometer and the hair hygrometer.
   (e) The meaning of air-conditioning; humidifiers.

6. **Force and Weight.** (Four periods.)
   (a) Recall that the pressure of a liquid is due to weight (a force); consideration of other types of force such as muscular exertion, tension in a cord, friction, elasticity of a spring.

(b) Experimental investigations of (i) the measurement of a force by the extension of a spring, (ii) Hooke's Law, by the elongation of a steel wire under stress.
(c) The weight or pull of the earth on a mass of one pound or one gram as a unit of force.
(d) The spring balance.
(e) The use of the units of weight for the measurement of non-gravitational forces.
(f) The graphic representation of a force.

7. **Transmission of Pressure.** (Two periods.)
The transmission of pressure by liquids; a brief discussion of Pascal's Law in conjunction with the study of hydraulic braking systems.

8. **Molecular Forces in Liquids.** (Two periods.)
A simple experiment to show the rise of liquids in capillary tubes. A brief explanation of capillary action, with reference to such common examples in the trades as the loss of seal in a plumber's trap by accumulation of lint, wick humidifiers, wetting of the undersides of shingles, soaking of timbers, wetting of outer walls of buildings, and the lubrication of closely fitted bearings.

9. **Forces and Motion.** (Two periods.)
Simple experiments to illustrate the meaning of inertia. Newton's First Law of Motion; the purpose of fly-wheels; the inertia starter for aeroplane engines.

10. **Work, Energy and Power.** (Ten periods.)
(a) Simple experiments with the lever and the single fixed pulley to show the relation between force and load; the use of these machines to explain the meaning of work; the foot-pound as a unit of work.
(b) Experimental and mathematical determination of the mechanical advantage of the following machines: (i) wheel and axle, (ii) a pair of toothed gears, (iii) simple pulley systems.
(c) The meaning of energy; a simple discussion of the various common forms of energy; kinetic and potential energy.
(d) A discussion of the role of friction, its advantages and disadvantages, with reference to the automobile clutch, brakes, and tires.
(e) Experiments to show the production of heat energy: by combustion (transformation of chemical potential energy); by compression (transformation of kinetic energy); by friction (transformation of kinetic energy); by the impact of a moving body (quick transformation of kinetic energy); by an electric current (transformation of electrical energy); by the absorption of radiation (transformation of radiant energy).
(f) Experiments with a model steam engine and a turbine, and reference to the gasolene engine to illustrate the transformation of energy; the meaning of power; the horse-power.

NOTE.—Pupils should be given an opportunity for ample experimental study before an attempt is made by the teacher to classify the forms of energy.

11. Magnetism. (Four periods.)

(a) An experiment to locate magnetic poles by the attraction of iron filings to a bar magnet.
(b) An experiment to locate the position of rest of a suspended or pivoted magnet.
(c) Experiments to demonstrate magnetic attraction and repulsion and to identify the poles of a magnet.
(d) The earth a magnet; magnetic compass.
(e) An experiment to demonstrate the magnetic field of force about a bar magnet by using iron filings or small compasses.

12. Current Electricity. (Eleven periods.)

(a) An experiment to show the production and detection of a current from a voltaic cell. The dry cell as a special form of the voltaic cell.
(b) Experiments to demonstrate the magnetic effect of an electric current (i) flowing through a straight wire, (ii) flowing through a solenoid, with and without a core.
(c) Experimental investigation of the factors affecting the strength of an electro-magnet.
(d) An examination of such electro-magnets as are found in electric bells, relays, circuit breakers, automobile cut-outs, lifting magnets; electro-magnetic sorting.
(e) An experiment to classify electrical conductors and non-conductors.
(f) An experiment to show the transformation of electrical energy into heat energy; reference to electric heaters, fuses, and lamps.
(g) Switches, fuses, short circuits, danger of "grounds" in household circuits; the necessity for grounding such appliances as high-speed presses and gasolene tank trucks.
(h) An elementary discussion of electrical units—volt, ampere, watt, kilowatt-hour in relation to common electrical appliances and in payment for electrical energy.

13. Composition of Air. (Two periods.)

An experiment comparing the rusting of damp iron in air and in oxygen (obtained from a cylinder or other source) to show:

(i) that oxygen is essential for the rusting of iron;
(ii) that oxygen is removed from air by this method;
(iii) the approximate percentage by volume of oxygen and nitrogen in the air.

14. Combustion in Oxygen and in Air. (Six periods.)

(a) Experimental illustration of the combustion of iron in oxygen; comparison with the slow oxidation (rusting) of iron in air.
(b) Experiments to show the combustion in oxygen of charcoal (carbon), sulphur, and magnesium; physical properties of the products.
(c) Combustion of fuels: a chemical reaction (oxidation) producing heat energy; experiments to show by the production of carbon dioxide and water that fuels contain carbon and, in most cases, hydrogen; recall dripping of water from cold automobile exhaust pipes.

(d) An experiment to show the combustion of (i) gasolene vapour, (ii) illuminating gas when mixed with air in varying proportions; a brief discussion of the characteristics of gasolene, fuel oil, and illuminating gas and of the hazards involved in using them.

15. Fighting Fire. (Two periods.)

Experiments to illustrate the two general methods of extinguishing a fire—by cooling and by smothering; a discussion of effective methods for fighting incipient fires.

16. Corrosion. (Four periods.)

(a) A brief discussion of the atmospheric oxidation of such metals as iron, steel, and copper.

(b) The classification of fluxes as used for soldering; chemical cleaning and surface covering.

(c) An experiment to show the action of chemical cleaning fluxes upon oxidized copper.

(d) Protection from corrosion (surface coatings):
  (i) Paint, varnish, lacquer.
  (ii) Galvanizing and tin plating.
  (iii) Electro-plating; simple experiment without theory.

17. Metals and Alloys. (Three periods.)

(a) A brief discussion of the composition, characteristics, and uses of cast iron, wrought iron, carbon steel, plumbers' fine solder, wiping solder, brazing solder, low melting point alloys such as fuse metal and sprinkler plugs, type metal, bearing metal, and stainless steel.

(b) An experiment to illustrate the production of an alloy by the preparation of a small quantity of fine solder.

18. Oxides of Carbon. (Seven periods.)

(a) An experiment to show (i) the solubility of carbon dioxide in water, and (ii) the effect of this solution on litmus. Compare the effect of other acids on litmus.

(b) An experiment to show the action of a solution of carbon dioxide on a fine suspension of precipitated chalk in water.

(c) The application to weathering of limestone:
Recall the hardness of water; using the above solutions demonstrate (i) the cause of hardness of water, (ii) the cause of deposition of scale in a kettle.

(d) A brief discussion of the formation of carbon monoxide by the incomplete combustion of carbonaceous fuels, with particular reference to the automobile engine.

(e) The dangerous properties of carbon monoxide; precautionary measures, and treatment for its effects by artificial respiration.

19. Solutions. (Four periods.)

(a) Recall the use of water as a solvent.

(b) The composition and characteristics of anti-freeze solutions and of storage battery electrolyte; experiments, (i) to determine the density of these solutions by means of an hydrometer, and (ii) to show their capacity to conduct a current of electricity; application of the information obtained from the density readings; a brief discussion of the industrial use, as solvents, of water, alcohol, acetone, and lacquer solvents.

20. Lubrication and Lubricants. (Five periods.)

(a) A brief explanation of the action of lubricants; recall the production of heat energy from kinetic energy by friction, and discuss the need for the lubrication of machines.

(b) The types of lubricants used for an automobile and the viscosity meaning of their S.A.E. ratings.

(c) Experiments with a lubricating oil (i) to show the effect of temperature changes on its viscosity, (ii) to determine its flash point.

(d) The suspension of fine particles in used automobile engine oil and their removal in the oil filter; compare suspensions and solutions.

21. Materials. (Four periods.)

A brief discussion of the composition and characteristics of such shop materials as glue, abrasives, pumice, rotten stone, putty, galvanized iron, tin-plate, copper, brass, bronze.

22. The Composition and Classification of Foods.

(a) Water in Foods. (Two periods.)
Experiments to show that foods contain water, and to show how the percentage of water may be determined in such foods as fresh vegetables, fresh fruits, cereals, butter.

(b) Carbohydrates. (Four periods.)
An experiment to detect the presence of starch in flour, potatoes, etc. An experiment to contrast sugar with starch in respect to solubility and taste. An experiment to show the presence in starch of (i) carbon, (ii) hydrogen and oxygen (as shown by the condensation of water).
An experiment to show the conversion of starch to sugar (i) by the action of saliva, or (ii) by boiling with dilute hydrochloric acid. (Note change in appearance, action on hot Fehling's solution or Benedict's solution.)

(c) Fats. (Two periods.)
Experiments to show that fats (i) are insoluble in water, (ii) are soluble in carbon tetrachloride, (iii) produce a persistent greasy translucent spot on paper.
An experiment to detect the presence of fat in butter, nuts, cheese, whole milk, etc.

(d) Proteins. (Two periods.)
Proteins—the composition and occurrence; experiments to show (i) that proteins are characterized by a disagreeable odour when being charred, (ii) the spot test with nitric acid and ammonium hydroxide.

(e) Mineral Salts. (Two periods.)
An experiment to show the presence of ash or mineral matter in such foods as rolled oats and potatoes, by gently burning until combustion is complete.

(f) The Combustion of Common Foods. (Five periods.)
A discussion of the role of carbohydrates, proteins, fats, mineral salts, and water in the diet, and the relative proportions of the food constituents as listed above in such common foods as flour, rice, beans, honey, butter, lard, salad oil, peanut butter, meat, eggs, fish, cheese.
Experiments to show that milk contains (i) water, (ii) sugar, (iii) fat, (iv) casein and albumen, (v) mineral matter; the value of milk as a food.

(g) A Brief Discussion of the Carbon Cycle. (One period.)
Recall photosynthesis, stressing the absorption of energy in a reaction which is the reverse of the oxidation of carbon-containing substances.

23. The Human Body.

(a) The Cell. (Four periods.)
Recall the structure of a plant cell. Microscopic observation of a simple cell such as cheek epithelium to show cell wall, cytoplasm and nucleus: growth (i) by increase in size of cells, (ii) by increase in the number of cells (cell division).
The cell as an organism with the functions of nutrition, motility, and secretion. (If possible, the living amoeba or paramoecium should be examined by the pupils.)
The meaning of tissues, organs, systems.

(b) Digestion and Absorption. (Four periods.)

NOTE.—If section 22 has been studied, the following experiments on carbohydrates, fats, and proteins should be omitted.

Carbohydrates—an experiment to show the presence in starch of (i) carbon, (ii) hydrogen and oxygen (as shown by the condensation of water).
An experiment to show the conversion of starch to sugar by the action of saliva.
Fats—the composition of fats; experiments to show that fats (i) are insoluble in water, (ii) soluble in carbon tetrachloride, (iii) produce a persistent greasy translucent spot on paper.
Proteins—the composition and occurrence of proteins; experiments to show (i) that proteins are characterized by a disagreeable odour on charring, (ii) the spot test with nitric acid and ammonium hydroxide.
The meaning of digestion; the alimentary canal; a brief discussion of digestive changes taking place in each of the parts; glands and juices taking part in these changes.
Absorption of digested food.

(c) Circulation, Respiration and Excretion. (Seven periods.)
The blood and the lymph: observation of the circulation of blood in the web of a frog's foot or in a tadpole's tail; microscopic examination of a drop of blood diluted with physiological saline solution (0.9% common salt).

The constituents of the blood and their functions.

The circulation of the blood in the human body (names of arteries and veins not required); the changes taking place in the tissues, the kidneys, and the lungs.

Protection from disease by the formation of anti-bodies.

An experiment to show that exhaled air contains more carbon dioxide than air in a room; the meaning of respiration (energy transformations). The organs of breathing; the great surface area in the lungs; how breathing is carried on.

24. Elementary Mineralogy. (Eighteen periods.)

NOTE.—With the approval of the Minister, this topic may be substituted for topic number 22.

Physical Mineralogy:

(a) Physical properties of minerals (omit hardness).

(b) Scale of hardness as used in the identification of minerals.

(c) Identification of quartz—massive, jasper, flint; identification of feldspars; comparison of orthoclase and plagioclase feldspars.

(d) Native minerals—identification of gold, silver, copper, sulphur, graphite, coal.

(e) Sulphides and arsenides—identification of iron pyrites, copper pyrites, galena, molybdenite, smaltite, zinc blende.

(f) Chlorides, fluorides, and carbonates—identification of halite, fluorite, calcite, dolomite, magnesite, malachite, azurite.

(g) Silicates—identification of hornblende, augite, garnet, olivene, epidote, tourmaline, mica, chlorite, serpentine, kaolin.

(h) Phosphates and sulphates—apatite, barite, celestite, gypsum, wolframite, scheelite.

Rocks:

(a) Common rock-forming minerals.

(b) Definition of a rock; classification of rocks.

(c) Igneous rocks—formation; identify granite, syenite, diorite, gabbro, diabase basalt, fine-grained, even-textured rocks such as felsite and basalt, very fine-grained glossy rocks such as porphyry.

(d) Sedimentary rocks—formation; identify conglomerate, breccia, sandstone, shale.

(e) Metamorphic rocks—formation; identify gneiss, schist, quartzite, slate.

Chemical Mineralogy:

(a) The use of the blow-pipe; reduction and oxidation of litharge in the blow-pipe flame.

(b) Identification of arsenic, antimony, bismuth, copper, iron, lead, silver, and sulphur, by means of chemical tests.

HOME ECONOMICS AND COMMERCIAL DEPARTMENTS

1. **Heat Units.** (Four periods.)
   (a) Comparison of Fahrenheit and Centigrade scales by means of a graph.
   (b) An experiment to illustrate the meaning of quantity of heat; the distinction between quantity of heat and temperature; the calorie and the British thermal unit.
   (c) An experiment to show that different substances have different heat capacities; the importance of the high heat capacity of water in relation to climate.

2. **Change of State.** (Four periods.)
   (a) Experiments to show absorption of heat without change in temperature when ice melts and when water boils; the use of ice in refrigerating and of steam in heating and cooking.
   (b) An experiment to show cooling by evaporation; the principle of artificial refrigeration.

3. **Hygrometry.** (Four periods.)
   (a) Recall presence of water vapour in the air.
   (b) An experiment to determine dew-point; meaning of relative humidity; experiments with the wet and dry bulb hygrometer and with the hair hygrometer.
   The meaning of air-conditioning; humidifiers.

4. **Force and Weight.** (Three periods.)
   (a) Recall that the pressure of a liquid is due to weight (a force).
   (b) Consideration of other types of force such as muscular exertion, tension in a cord, friction, elasticity of a spring.
   (c) Experimental measurement of force by the extension of a spring; the weight or pull of the earth on a mass of one pound or one gram as a unit of force; the spring balance.
   (d) The use of the units of weight for the measurement of non-gravitational forces.

5. **Work, Energy, and Power.** (Six periods.)
   (a) Simple experiments with the lever and the single fixed pulley to show the relation between force and load; the use of these machines to explain the meaning of work; the foot-pound as a unit of work.
   (b) A discussion of the role of friction, its advantages and disadvantages.
   (c) A brief discussion of the production of heat energy: by combustion (transformation of chemical potential energy); by compression (transformation of kinetic energy); by friction (transformation of kinetic energy); by the impact of a moving body (quick transformation of kinetic energy); by an electric current (transformation of electrical energy); by the absorption of radiation (transformation of radiant energy).
   Experiments to illustrate as many of these as possible.

6. **Magnetism.** (Four periods.)
   (a) An experiment to locate magnetic poles by the attraction of iron filings to a bar magnet.
   (b) An experiment to locate the position of rest of a suspended or a pivoted magnet.
   (c) Experiments to demonstrate magnetic attraction and repulsion and to identify the poles of a magnet.
   (d) The earth a magnet; magnetic compass.
   (e) An experiment to show magnetization of a knitting needle by stroking with a bar magnet; reference to the transformation of a part of the kinetic energy used in this process into magnetic potential energy.

7. **Static Electricity.** (Two periods.)
   Experiments to show the electrification of ebonite rubbed with fur and of glass rubbed with silk; the hazards of static electricity.

8. **Current Electricity.** (Nine periods.)
   (a) An experiment to show the production and detection of a current from a voltaic cell.
   (b) The dry cell as a special form of the voltaic cell.
   Repeat the experiment on the electrolysis of water.
   (c) A brief discussion of the transformation of electrical energy into heat energy in the electric lamp, toaster, and fuse.
   (d) An elementary discussion of electrical units; volt, ampere, watt, and kilowatt-hour in relation to common electrical appliances and in payment for electrical energy.
   (e) Switches, fuses, short circuits, danger of "grounds" in household circuits.
   (f) Experiments to show the magnetic effect of an electric current (i) in the deflection of a compass needle, (ii) in the electro-magnet.

9. **Composition of Air.** (Two periods.)
   An experiment comparing the rusting of damp iron in air and in oxygen (obtained from cylinder or other source) showing (i) that oxygen is essential for the rusting of iron, (ii) that oxygen is removed from air by this method, (iii) the approximate percentage by volume of oxygen and nitrogen in the air.

10. **Combustion in Oxygen and in Air.** (Six periods.)
   (a) An experiment to show the combustion of iron in oxygen; comparison with the slow oxidation (rusting) of iron in air.
   (b) Experiments to show the combustion in oxygen of carbon (charcoal), sulphur, and magnesium; physical properties of the products.
   (c) Combustion of fuels: a chemical reaction (oxidation) producing heat energy; experiments to show by the production of carbon dioxide and water that fuels contain carbon and, in most cases, hydrogen; recall dripping of water from cold automobile exhaust pipes.
   (d) Discussion of the dangerous properties of combustible gases such as gasolene vapour, fuel oil vapour, and illuminating gas and of effective methods of extinguishing incipient fires.

11. Protection from Corrosion. (Two periods.)

(a) Surface coating: paint; galvanizing and tin-plating; electro-plating (a simple experiment without theory).

(b) Alloys: a brief discussion of such non-corrosive alloys as stainless steel.

12. Carbon Dioxide and Weathering of Rocks. (Four periods.)

(a) An experiment to show (i) the solubility of carbon dioxide in water, and (ii) the effect of this solution on litmus; comparison of the effect of other acids on litmus.

(b) An experiment to show the action of a solution of carbon dioxide on a fine suspension of precipitated chalk in water; the application to the weathering of limestone; the use of the above solution to demonstrate (i) the cause of hardness of water, (ii) the cause of the deposition of scale in a kettle.

13. Home and Industrial Uses of Carbon Dioxide. (Three periods.)

The use of carbon dioxide obtained from baking soda and yeast in baking; the use of carbon dioxide in carbonated beverages, fire extinguishers, and as dry ice.

14. Fundamental Functions of Plants and Animals. (One period.)

Recall manufacture of food by plants; dependence of animals on plants for food and oxygen; use by plants of carbon dioxide produced by animals.

15. Fungi. (Twelve periods.)

(a) Culture of bread mould, and microscopic examination of the mycelium, sporangium, and spores; prevention of moulds.

(b) The mushroom as a plant; vegetative and reproductive parts; mode of life; recognition of the common meadow mushroom and of the poisonous Amanita.

(c) Culture of yeast in sugar solution, and collection and identification of carbon dioxide; microscopic examination of yeast cells; economic importance.

(d) Bacteria:

What they are and where they occur; beneficial and harmful kinds; laboratory demonstration by the use of Petri dishes and agar to show development of colonies of bacteria.

Experiments to show (i) pasteurization of milk, (ii) sterilization of milk and of canned foods; water pollution; purification of water by boiling; use of chloride of lime as a disinfecting agent; infectious diseases, e.g., tuberculosis, typhoid fever, diphtheria; discussion of agents of infection, such as house flies, drinking cups, etc.

16. The Composition and Classification of Foods. (Eighteen periods.)

For details of this topic see topic number 22 of the Industrial Course.

17. The Human Body. (Ten periods.)

For details of this topic see topic number 23 of the Industrial Course.

18. Textiles (Twenty-six periods.)

(a) A microscopic examination of representative fibres to note the differences in appearance.

(b) Burning tests to distinguish the various fibres.

(c) A study of the natural history of linen to include the growth of the flax plant, water and dew retting, and the preparation of the fibre for spinning and weaving.

NOTE.—This discussion is to correlate and apply the fundamental principles previously studied in such topics as the living plant and bacteria.

(d) The origin and preparation of other fibres (plant, animal, artificial) should be briefly discussed.

(e) Experiments to show (i) that textiles contain water combined both mechanically and chemically, (ii) that the amount of water absorbed by textiles varies with the kind of fibre and the humidity of the air.

(f) Experiments to show the relation of cotton, linen, and rayon to carbohydrates in foods by testing for the presence of (i) carbon, (ii) hydrogen and oxygen (as shown by the condensation of water).

(g) Experiments to show the relation of animal fibres (wool and silk) to proteins in food by repeating the protein tests as given above.

ART DEPARTMENT

1. Fundamental functions of plants and animals. (Two periods.)

(a) Recall manufacture of food by plants; dependence of animals on plants for food and oxygen; use by plants of carbon dioxide by animals.

(b) Animals in relation to man's interests.
Various forms of animal life; domesticated animals; value of wild animals; reference to economic importance of insects.

2. Insects. (Eighteen periods.)

NOTE.—Section 22 of the Industrial Course may be substituted for this topic.

(a) Habits, structure, and life history. (Ten periods.)

(i) A study of the living grasshopper; its habits (breathing, locomotion, feeding, etc.)

(ii) A study of the main external features of the grasshopper and one other insect to show fitness for their mode of life; the life history of the grasshopper.

(iii) A study of the general characteristics of insects; rate of reproduction; natural control factors.

(b) Harmful and beneficial types. (Four periods.)
A brief survey of insects injurious to plants, to animals, to household goods, and to man; nature of injury and methods of control.

(c) Social insects. (Four periods.)
A study of the life history, habits, and economic importance of the honey bee.

3. The Heavens. (Sixteen periods.)

Instructions for the following observations should be given at the opening of school in September.

(a) The Sun.
Observation of the position of the sun (i) at different times of a single day, (ii) at noon from week to week, (iii) at sunrise and sunset from week to week; observation of the variation in the length and direction of shadow in (i) and (ii).

(b) The Moon.
Observation of the position of the moon at different hours of a single evening; observation of its position and appearance at the same hour for successive evenings.
Observation of the position of the full moon at rising and of the elevation of its path above the southern horizon at various seasons of the year.

(c) The Stars.
Observations of the position of the great dipper (i) at different hours in the same evening, (ii) at the same hour in successive months; recognition of at least three other constellations; recognition of the milky way; observation of the position of the polar star; recognition of at least three stars of first magnitude.

(d) The Planets.
Recognition of two planets, and observation of the change in position of one of them; observation with field or opera glasses of four of the moons of Jupiter.

(e) Meteors.
Report of meteors observed during the school year, with special attention to meteoric showers occurring in October, November, December, and April.

NOTE.—It is assumed that a total of eight periods during the school year will be required for the discussion of the above observations.

(f) Movements and Distances of the Heavenly Bodies. (Two periods.)
(i) The diurnal rotation of the earth; the annual revolution of the earth; the revolution of the moon about the earth; the rotation of the moon on its axis.
(ii) The solar system: explanation of apparent movements of heavenly bodies; distance relations of sun, moon, planets, stars.
(iii) The meaning of light year.

(g) Shadows and Eclipses. (Three periods.)
Rectilineal propagation of light; an experiment to show the formation of shadows (umbra and penumbra); explanation of solar and lunar eclipses.

(h) Luminosity of Heavenly Bodies. (Three periods.)
Luminous and non-luminous bodies; difference between diffuse and regular reflection; explanation of luminosity of the moon, of the planets, and of meteors; explanation of the appearance of the moon at different phases.

4. Energy.

(a) Heat Units. (Four periods.)

(i) Comparison of Fahrenheit and Centigrade scales by means of a graph.

(ii) An experiment to illustrate the meaning of quantity of heat; the distinction between quantity of heat and temperature; the calorie and the British thermal unit.

(iii) An experiment to show that different substances have different heat capacities; the importance of high heat capacity of water in relation to climate.

(b) Change of State. (Four periods.)

(i) Experiments to show absorption of heat without change in temperature when ice melts and when water boils; the use of ice in refrigerating and of steam in heating.

(ii) An experiment to show cooling by evaporation; the principle of artificial refrigeration.

(c) Hygrometry. (Four periods.)

(i) Recall the presence of water vapour in the air.

(ii) An experiment to determine dew-point.

(iii) Meaning of relative humidity; measurement of the relative humidity of the air in the classroom by means of the wet and dry bulb hygrometer and the hair hygrometer.

(iv) The meaning of air-conditioning; humidifiers.

5. Light.

(a) The Solar Spectrum. (Four periods.)

(i) A discussion of light as radiant energy.

(ii) An experiment to show the composite nature of white light.

(iii) An examination of the colours of the solar spectrum, with a brief discussion of relative wave lengths.

(b) Transmission of light. (One period.)

The meaning of the terms transparent, translucent, and opaque.

(c) The eye. (Four periods.)

(i) A discussion of the action of the eye in receiving an image, as compared with a camera.

(ii) The capacity for distinguishing chromatic colours, and its absence in cases of colour blindness.

(d) The Colour of Bodies in White Light. (Three periods.)

(i) An experiment to show that the colour of a body in white light depends upon the nature of the light waves which it reflects.

(ii) A brief discussion of transparent glazes and of water-colour paints as absorbers of various light waves.

(e) The Colour of Bodies in Coloured Light. (Three periods.)

An experiment to show that a body which appears white in sunlight assumes the colour of any part of the spectrum in which it is placed. An experiment to show that a body having colour in white light reflects wave lengths of that colour and absorbs light of other wave lengths.

(f) The Colour of Bodies in Artificial Light. (Three periods.)

(i) A discussion of the composition of artificial light as compared with sunlight.

ii) The effect of lack of some light waves in artificial light on the colour of coloured bodies, as, for example, the colour of a red pigment under a mercury vapour lamp, or of blue and violet pigments under the incandescent lamp; stage lighting for colour effects.

(g) Reflection of Light. (Three periods.)
  (i) An experiment to illustrate the relative intensity of the light reflected (luminosity) by chromatic and achromatic colours under similar illumination.
  (ii) A discussion of the application of relative intensity of reflection to simple practical uses of colour.

(h) Complementary Colours. (Four periods.)
An experiment (i) to show the re-combination of the colours of the spectrum into white light, and (ii) to find the complement of a spectral colour by subtracting this colour from the spectrum before it is re-combined. This experiment may be performed by using a light source, a prism and a lens, or a colour disc.

(i) Pigments. (Four periods.)
  (i) An experiment to compare the colour obtained by the addition of a yellow pigment to a blue pigment with that obtained by the addition of yellow light to blue light.
  (ii) A discussion of the behaviour of mixtures of pigments as compared with mixtures of light as regards the resultant colour effect.
  (iii) A brief discussion of modern colour theories, distinguishing between pigmentary and light theories.
  (iv) A discussion of the reduction of a pigment of a pure hue by the addition of black and white.

6. Air.

(a) Composition of Air. (Two periods.)
An experiment comparing the rusting of damp iron in air and in oxygen (obtained from cylinder or other source) showing (i) that oxygen is essential for the rusting of iron, (ii) that oxygen is removed from air by this method, (iii) the approximate percentage by volume of oxygen and nitrogen in the air.

(b) Combustion in Oxygen and in Air. (Six periods.)
  (i) An experiment to show the combustion of iron in oxygen; comparison with the slow oxidation (rusting) of iron in air.
  (ii) Experiment to show the combustion in oxygen of carbon (charcoal), sulphur, and magnesium; physical properties of the products.
  (iii) Combustion of fuels: a chemical reaction (oxidation) producing heat energy; experiments to show by the production of carbon dioxide and water that fuels contain carbon and, in most cases, hydrogen; recall dripping of water from cold automobile exhaust pipes.
  (iv) Discussion of the dangerous properties of combustible gases such as gasolene vapour, fuel oil vapour, and illuminating gas, and of effective methods of extinguishing incipient fires.

(c) Protection from Corrosion. (Two periods.)
  (i) Surface coating; painting; galvanizing and tin-plating; electroplating (a simple experiment without theory).

(ii) Alloys: a brief discussion of such non-corrosive alloys as stainless steel.

(d) Carbon Dioxide and Weathering of Rocks. (Four periods.)
  (i) An experiment to show (a) the solubility of carbon dioxide in water and (b) the effect of this solution on litmus. Compare the effect of other acids on litmus.
  (ii) An experiment to show the action of a solution of carbon dioxide on a fine suspension of precipitated chalk in water; the application to the weathering of limestone.
  (iii) Recall the hardness of water and, using the above solution, demonstrate (a) the cause of hardness of water, (b) the cause of deposition of scale in a kettle (due to loss of carbon dioxide).

(e) Home and Industrial Uses of Carbon Dioxide. (Two periods.)
  (i) Its use in baking as shown by the practice of using baking soda and yeast.
  (ii) Its use in carbonated beverages, fire extinguishers, and as dry ice.

7. **The Drying of Paints.** (Two periods.)
An experiment to illustrate the drying of paints (i) by evaporation (alcoholic shellac used to fix a drawing), (ii) by absorption (painting on absorbent stock), and (iii) by oxidation (the oxidation of linseed oil to form a tough, transparent film).

8. **Pulp and Paper.** (Five periods.)
(a) A brief history of paper-making.
(b) A discussion of the character and uses of the common paper-making fibres as obtained from straws, jute, manilla, hemp, rags, and wood. Reference to the difference in method of separating the fibres in ground-wood pulp and chemical pulp.
(c) A simple explanation of the making of paper from rags and wood pulp.
(d) The purpose of sizing and coating paper.

9. **Textile Fibres.** (Fourteen periods.)
(a) A microscopic examination of representative fibres to note the differences in appearance.
(b) Burning tests to distinguish the various fibres.
(c) Brief discussion of the origin, characteristics, and uses of the following fibres: flax, cotton, silk, wool, and wood cellulose.

10. **The Human Body.** (Fifteen periods.)
For details of this course see topic number 23 of the Industrial Course.

AGRICULTURAL DEPARTMENTS

The Science Course for Agricultural Departments will consist of the topics in Science prescribed for Agricultural Science of Grade X of the General Course.

REFERENCE BOOKS

Elementary Vocational Science—The Ryerson Press.
Everyday Problems in Science—W. J. Gage & Company, Limited.

Grades XI and XII

INDUSTRIAL DEPARTMENTS

These Courses of Study have been based upon an examination of the scientific requirements of the Shopwork Courses for Vocational Schools.

The presentation of many of the topics in these courses requires discussion by the class. The students should be encouraged, therefore, to make use of suitable reference and illustrative materials, which should be available in a properly indexed form.

Where the scientific principles involved in the study of Electricity, as outlined in these courses, are taught to certain groups in the electrical laboratory, these students should be exempted from the study of this topic. It is recommended that the time allotted for the study of Electricity be devoted to the study of some related optional topics as listed in the Grade XII course.

If time permits, the courses in Vocational Chemistry may be amplified by a study of materials of local importance.

No time allotments have been indicated in the Grade XII course, in order that there may be greater flexibility within the course, and that the time necessary to treat the topics as student-research projects may be made available.

A list of additional research topics is provided at the end of the course in Grade XII Physics. It is suggested that the scientific principles previously outlined be applied in the further study of these topics. Not more than ten per cent of the time should be devoted to this study.

PHYSICS, GRADE XI

Accurate measurements. (Five periods.)

A review of the units of linear measurement in the English and metric systems.

Practice in making fine measurements with a steel rule and calipers.

The construction and use of a vernier scale.

Practice in the use of a micrometer.

Principles and practical applications of machines. —Levers. (Three periods.)

A study of the three classes with an experimental determination of the mechanical advantage of each.

The classification and the use of such levers as are found in the shops.

The determination of the mechanical advantage of such bent levers as the claw hammer and the automobile brake lever.

—Wheel and axle. (One period.)

A review of the wheel and axle and of toothed gears.

—Pulleys. (Two periods.)

A review of pulley systems.

The construction, mechanical advantages and uses of the differential pulley.

—Inclined plane. (Four periods.)

The experimental determination of the mechanical advantage of an inclined plane.

The wedge and the screw as adaptations of the inclined plane.

A study of practical applications of the wedge as in the cam and the carpenter's plane; and of the screw as in the jackscrew and the vise.

Electricity.
—Review. (Three periods.)

A review of current electricity, Grade X, section 12, parts (a), (b), and (c).

—Meaning of potential difference. (Four periods.)

Review the meaning of work, energy and power, with emphasis on gravitational potential energy.

—Direct current motor (Two periods.)

A simple experiment to illustrate the principle of the D.C. motor. (Details of the structure of the motor are not required.)

—Ohm's Law. (Nine periods.)

A review of electrical units, Grade X, section 12, part (h).

An experiment to determine the resistance of a conductor using the voltmeter-ammeter method.

Simple problems involving Ohm's Law.

—Alternating current (A.C.). (Two periods.)

Simple experiments to show the production of an alternating current: (1) using a bar magnet, coil and galvanometer, and (2) using an electro-magnet to replace the bar magnet.

Light.
—Solar spectrum. (Four periods.)

A discussion of light as radiant energy.

An experiment to show the composite nature of white light.

An examination of the colours of the solar spectrum, with a brief discussion of relative wave lengths.

—Transmission of light. (One period.)

The meaning of the terms transparent, translucent, and opaque.

—Reflection and refraction. (Five periods.)

Experiments to illustrate the reflection of light from plane surfaces, and from curved surfaces.

Experiments to illustrate the refraction of a parallel beam of light in passing through a rectangular block of glass, and through a double convex lens.

Experiments to illustrate the refraction of light as it passes from one substance to a substance of different density, and its application to the prism and the convex lens.

A brief discussion of the applications of reflection and refraction of light in modern lighting systems.

—The eye. (Two periods.)

A discussion of the action of the eye in receiving an image, as compared with a camera.

—Colour of bodies in white light. (One period.)

An experiment to show that the colour of a body in white light depends upon the nature of the light waves which it reflects.

—Colour of bodies in coloured light. (One period.)

An experiment to show that a body which appears white in sunlight assumes the colour of any part of the spectrum in which it is placed.

Sound. (Five periods.)

Simple experiments to investigate (1) the origin of sound, (2) the difference in sounds of regular and irregular vibrations, (3) the relation of pitch to vibration number.

A brief discussion of the importance of a knowledge of the nature of sound in locating and correcting defects in machines such as dry bearings, improper meshing of gears, brush contacts in electrical machinery, and body noises in automobile chassis.

A simple experiment to illustrate the effectiveness of sound insulating materials.

A brief discussion of the use of these materials in reducing the transmission of sound as in automobile bodies, machine mountings, and buildings.

CHEMISTRY, GRADE XI

Wood. (Twelve periods.)

A brief discussion of the chemical composition of wood.

Recall the combustion in oxygen and in air, Grade X, section 14.

An experiment to show the effect of heat on wood at various temperatures to the kindling temperature.

A discussion of the meaning of kindling temperature.

A discussion of wood as a fire hazard.

An experiment to illustrate the protection of wood against fire by covering the wood with a fireproof coating such as sodium silicate.

A brief discussion of the use of other protective coverings such as plaster, concrete, whitewash, and asbestos.

An experiment to illustrate the reduction of the fire hazard by impregnating the wood with such chemicals as ammonium phosphate, ammonium sulphate, or borax.

A discussion of the function of these volatile, non-combustible chemicals in diluting the combustible gases given off by the hot wood.

A brief discussion of the fungus decay of wood, and of the conditions necessary for the development of fungi in wood.

Experiments to illustrate the open-tank process and the Kyanizing process for the preservative treatment of wood.

A brief discussion of the methods employed for impregnating wood with preservatives.

The application of kiln drying for the preservation and seasoning of wood.

Refer to the use of paint, varnish, and lacquer for protection from corrosion, Grade X, section 16, part (d), and discuss their application to the preservation of wood.

An experiment to compare the effect of air upon a thin film of linseed oil and of mineral oil.

Spontaneous combustion. (Two periods.)

Recall that combustion is a chemical reaction producing heat energy.

A brief discussion of the causes leading to spontaneous combustion with special reference to such materials as linseed oil, and coal dust.

Limestone and its products. (Five periods.)

A study of limestone, its composition, properties, and uses.

Quicklime; an experimental study of its preparation and properties.

The kinds of quicklime.

Slaked lime (hydrated lime); an experimental study of its preparation and properties.

The action of carbon dioxide on slaked lime.

An experiment to show the preparation of lime-sand mortar, its initial set, and final hardening.

A brief discussion of other uses of slaked lime.

Gypsum and its products. (Five periods.)

A study of gypsum, its composition, properties, and uses.

An experiment to show (1) the action of heat on a hydrate such as blue vitriol, and (2) the action of water on the anhydrous residue.

Experiments to show the conversion of gypsum into (1) plaster of Paris, and (2) "hard burned" plaster.

Experiments to show the effect of the addition of water to (1) plaster of Paris, and (2) "hard burned" plaster.

A discussion of other gypsum products such as wallboard, gypsum blocks, and acoustic plaster.

Portland cement and concrete. (Eight periods.)

A study of Portland cement, its composition and properties.

A brief outline of the manufacture of cement.

An experiment to illustrate the setting of Portland cement; a brief explanation of the initial set and of the final hardening.

Recall commercial refractory materials, Grade X, section 2, part (c), and compare the effect of heat on cement after setting.

A study of concrete, its composition and the function of each constituent.

A comparison of the setting of concrete with that of lime-sand mortar.

Recall the expansion of water on freezing, and discuss the application to the disintegration of concrete.

Recall the action of carbonic acid on limestone, and discuss the similar disintegrating action on the calcium salts in concrete.

The uses of concrete.

Petroleum oil products.
(Ten periods.)

A discussion of the world locations of petroleum oil, and the methods and channels of distribution, with specific reference to the requirements of the British Empire.

Experiments to illustrate (1) the distillation of water, and (2) the fractional distillation of a water-alcohol solution.

A discussion of the principles of fractional distillation to petroleum refining.

An experiment to show that within certain limits a mixture of gasolene vapour and air will produce an explosive mixture.

A brief discussion of types and grades of motor fuels.

A recall of lubrication and lubricants, Grade X, section 20.

An examination of other petroleum products, with a brief outline of their uses.

Iron and steel
(Seven periods.)

A discussion of the kinds and sources of iron ores.

A discussion of the construction of the iron blast furnace.

Reference to the heat exchange in the stoves.

A demonstration of carbon monoxide as a reducing agent.

Recall the dangerous properties of carbon monoxide, Grade X, section 18, part (e).

An examination of the constituents of the blast furnace charge.

A discussion of the purpose of each substance in the operation of the blast furnace.

A brief discussion of the composition and characteristics of cast iron, carbon steel, and wrought iron.

Density.

A review of the meaning of density.

The determination of the volume of (1) a regular solid such as a cylinder or a prism by linear measurements (using vernier calipers), (2) an irregular solid by displacement.

The measurement of the masses of these solids and the determination of their densities.

Experiments to determine the density of a liquid such as carbon tetrachloride by use of (1) specific gravity bottle, (2) a Westphal plummet, and (3) a hydrometer.

A discussion of methods which may be used to compare the densities of liquids, such as the balancing of immiscible liquids in a U-tube.

Simple problems involving the use of densities to determine volume-mass relations.

An experimental study of the construction of the hydrometer.

A discussion of the various hydrometer scales.

A discussion of the density of water at 4° C. and other temperatures.

A comparison of the meaning of specific gravity and density.

Force.

A review of the meaning of force.

Experiments to determine (1) the equilibrant of two forces acting in the same line (parallel forces), (2) the equilibrant of two forces acting at an angle. The relation of the resultant to the equilibrant.

An experiment to verify the law of the parallelogram of forces.

A discussion of the moment of a force.

A review of the wheel and axle to illustrate the effect of the moment of a force.

Steam heating.

Recall the hot-water heating system.

An experiment to illustrate the heat of condensation (heat of vaporization) of water.

A discussion of the use of steam for heating.

Air-conditioning.

A review of hygrometry.

A discussion of the relation of humidity to health, and of the methods employed for the conditioning of the air of buildings in winter and in summer.

A discussion of the insulation of buildings in relation to the transference of heat; and of air-conditioning.

Magnetic effect of an electric current.

Experiments to demonstrate the magnetic effect of an electric current (1) flowing through a straight wire, (2) flowing through a solenoid, with and without a core.

Experimental investigation of the factors affecting the strength of an electro-magnet.

The construction and action of a galvanometer, with a fixed magnet and a moving coil. (The D'Arsenval galvanometer.)

A discussion of the development of the moving-coil galvanometer into an instrument for measuring (1) current (ammeter), (2) voltage (voltmeter).

Simple experiments to illustrate the fundamental principles of (1) the motor, (2) the generator.

The use of a thermocouple and galvanometer to measure temperature (pyrometer).

Light.

A review of reflection and refraction as outlined in Grade XI.

A study of the various types of reflectors with respect to distribution of light rays.

A study of the accepted standards of intensities of illumination used in modern lighting as in (1) home, office, and factory, (2) display effects, (3) floodlighting.

A study of the principles involved and the use of a light meter in measuring the illumination in a room or building.

A discussion of the transmission of light by waves.

The meaning of plane polarized light.

Simple experiments to show the nature and effects of polarized light. (The use of a pair of polaroid discs is suggested.)

A discussion of the uses of such a substance as polaroid, with special reference to the elimination of glare from automobile headlights, and from smooth-surface reflections.

Additional topics.

Photography.
Electronics.
Air-conditioning.
Light-conditioning.
Refrigeration.
Mineralogy.

Combustion.

Experiments to show that certain mixtures of gasolene and air give complete combustion, and that others give incomplete combustion.

A discussion of complete and incomplete combustion of hydrocarbons.

Review the formation of carbon monoxide in the automobile engine, and during the combustion of coal or coke.

Experiments to illustrate the complete and incomplete combustion of acetylene.

The use of the oxy-acetylene flame for welding, with special reference to the correct mixture of oxygen and acetylene.

Repeat the experiment to show the burning of iron in oxygen.

The use of the oxy-acetylene flame for cutting, with special reference to the correct mixture of oxygen and acetylene.

An examination of the structure of the Bunsen burner and its flame.

A discussion of the complete and incomplete combustion of natural gas or coal gas.

A review of explosive mixtures with special reference to the "striking-back" of the flame of the Bunsen burner.

A study of the oxidizing and the reducing zones of the gas flame.

Acids, bases, and salts.

Experiments to show the combustion in oxygen of carbon, sulphur, and red phosphorus; the reaction of these oxides with water, and the effect of their solutions on litmus.

Acidic oxides—acid anhydrides.

An experiment to show the combustion of magnesium in oxygen.

A demonstration of the combustion of sodium in oxygen.

The reaction of these metallic oxides with water, and the effect of their solutions on litmus. Basic oxides.

Discover further properties of acids (dilute) using (1) other indicators, (2) action on carbonates, (3) action on suitable metals (magnesium), (4) taste as shown by soda water, vinegar, sour milk, etc.

Discover the effect of bases on the same indicators as used for acids.

Experiments to show the reaction between acids and bases; the products of the reaction (neutralization), water, and a salt which is left as a residue upon evaporation of the water.

The theory of the ionization of acids, bases, and salts.

A demonstration of the electrolysis of cupric chloride solution, with an explanation in terms of charged particles.

A discussion of the dissociation of hydrogen chloride when dissolved in water as giving rise to electrically charged particles, called ions.

A discussion of the hydrogen ion as being the characteristic ion of acids, and of the properties of acids (taste, effect on litmus and other indicators, action on metals, etc.) as being due to hydrogen ions in the solutions.

A discussion of the dissociation of sodium hydroxide in solution.

A discussion of the hydroxyl ion as being the characteristic ion of bases, and the properties of bases (taste, effect on litmus and other indicators, caustic action on animal and vegetable matter, etc.) as being due to hydroxyl ions in the solutions.

Neutralization.

A discussion of neutralization as being a quantitative reaction depending upon the removal of a hydrogen ion and a hydroxyl ion to form water.

A brief discussion of the measurement of acidity in terms of hydrogen ion concentration. The meaning of pH.

The lead storage cell (the storage battery).

An experiment to show the preparation of the electrolyte.

Recall the use of the hydrometer and discuss the use of the density-concentration tables.

An experiment to "form" a storage cell, using lead plates, with a discussion of the composition of the plates before and after forming.

A discussion of the charging of the cell with special reference to the transformation of electrical energy to chemical potential energy; and the discharging of the cell in terms of the transformation of energy.

The efficiency of the commercial storage battery—a comparison of the output of electrical energy to the input of electrical energy, with a discussion of the dissipation of some energy in heating the cell and decomposing the electrolyte.

Steel.

Review the construction and operation of the iron blast furnace.

A discussion of the construction and use of the iron cupola.

A review of the composition, characteristics, and uses of cast iron, carbon steel, and wrought iron.

A brief study of the manufacture of steel by (1) the acid Bessemer process, (2) the basic open-hearth process.

The heat treatment of steel—a discussion of the methods and purpose of annealing, hardening, and tempering of steel.

A discussion of the methods and purpose for surface hardening of steel articles by (1) case hardening, (2) nitriding.

Reference to the composition and characteristics of tool steels.

COMMERCIAL DEPARTMENTS

Since commercial pupils will have taken no science in Grade X, the General Science Course in Grade XI will continue from that of Grade IX. The subject matter should be presented through a practical laboratory course in which experimentation is carried on by the pupils working in small groups. In boys' classes, emphasis should be placed upon industrial application of the principles studied, while in girls' classes, the emphasis should be directed more to home activities.

GRADE XI

Animals and plants in relation to man's interests. (Two periods.)

Various forms of animal and plant life; domesticated animals; value of wild animals. Reference to economic importance of plants.

Fundamental relations of plants to animals. (One period.)

Recall manufacture of food by plants; dependence of animals on plants for food and oxygen; use by plants of carbon dioxide produced by animals.

Bread mould. (Two periods.)

Culture of bread mould and microscopic examination of the mycelium, sporangium, and spores.

Yeast. (Two periods.)

Culture of yeast in sugar solutions, and collection and identification of carbon dioxide; microscopic examination of yeast cells; economic importance.

Bacteria. (Five periods.)

What they are and where they occur; beneficial and harmful kinds; laboratory demonstration by the use of Petri dishes and agar to show development of colonies of bacteria; experiments to show (1) pasteurization of milk, (2) sterilization of milk and of canned foods; water pollution; purification of water by boiling; use of chloride of lime as a disinfecting agent; infectious diseases, e.g., tuberculosis, typhoid fever, diphtheria; discussion of agents of infection, such as house flies, drinking cups, etc.

The human body. —The cell. (Four periods.)

Recall the structure of a plant cell. Microscopic observation of a simple cell such as cheek epithelium to show cell wall, cytoplasm, and nucleus; growth (1) by increase in size of cells, (2) by increase in the number of cells (cell division).
The cell as an organism with the functions of nutrition, motility, and secretion. (If possible, the living amoeba or paramoecium should be examined by the pupils.)
The meaning of tissues, organs, systems.

—Digestion and absorption. (Six periods.)

Carbohydrates—an experiment to show the presence in starch of (1) carbon, (2) hydrogen and oxygen (as shown by the condensation of water).
An experiment to show the conversion of starch to sugar by the action of saliva.
Fats—the composition of fats; experiments to show that fats (1) are insoluble in water, (2) are soluble in carbon tetrachloride, (3) produce a persistent greasy translucent spot on paper.

Proteins—the composition and occurrence of proteins; experiments to show (1) that proteins are characterized by a disagreeable odour on charring, (2) the spot test with nitric acid and ammonium hydroxide.
The meaning of digestion; the alimentary canal; a brief discussion of digestive changes taking place in each of the parts; glands and juices taking part in these changes.
Absorption of digested food.

—Circulation, respiration, and excretion. (Seven periods.)

The blood and the lymph: observation of the circulation of blood in the web of a frog's foot or in a tadpole's tail; microscopic examination of a drop of blood diluted with physiological saline solution (0.9% sodium chloride).
The constituents of the blood and their functions.
The circulation of the blood in the human body (names of arteries and veins are not required); the changes taking place in the tissues, the kidneys, and the lungs.
Protection from disease by the formation of anti-bodies.
An experiment to show that exhaled air contains more carbon dioxide than air in a room; the meaning of respiration (energy transformation).
The organs of breathing; the great surface area in the lungs: how breathing is carried on.

Heat.
—Heat units. (Four periods.)

Comparison of Fahrenheit and Centigrade scales by means of a graph.
An experiment to illustrate the meaning of quantity of heat; the distinction between quantity of heat and temperature.
The calorie and the B.T.U.
Experiments to investigate the heat capacity of different substances.
The importance of the high heat capacity of water in relation to climate.

—Heat transference. (Four periods.)

Recall convection currents in water, and the hot-water heating system.
Experiments to investigate the heat conductivity of various metals.
An experimental study of commercial insulating materials.
A discussion of the use of insulating materials in building.

—Hygrometry. (Four periods.)

Recall presence of water vapour in the air.
An experiment to determine dew-point.
Meaning of relative humidity.
Measurement of the relative humidity of the air in the classroom by means of the wet and dry bulb hygrometer, and the hair hygrometer.
The meaning of air-conditioning; humidifiers.

Electricity. (Ten periods.)

An experiment to show the production and detection of a current from a voltaic cell. The dry cell as a special form of the voltaic cell.
An experiment to classify electrical conductors and non-conductors.
An experiment to show the transformation of electrical energy into heat energy; reference to electric heaters, fuses, and lamps.

A discussion of the efficiency of electric lamps; direct and indirect lighting; proper illumination for reading.
Switches, fuses, short circuits, danger of "grounds" in household circuits; the necessity for grounding.
An elementary discussion of electrical units—volt, ampere, watt, kilowatt-hour—in relation to common electrical appliances and in payment for electrical energy.

Light.

—The solar spectrum. (Four periods.)

A discussion of light as radiant energy.
An experiment to show the composite nature of white light.
An examination of the colours of the solar spectrum, with a brief discussion of relative wave lengths.

—Transmission of light. (One period.)

The meaning of the terms transparent, translucent, and opaque.

—The eye. (Four periods.)

A discussion of the action of the eye in receiving an image, as compared with a camera.
The capacity for distinguishing chromatic colours, and its absence in cases of colour-blindness.

—The colour of bodies in white light. (Three periods.)

An experiment to show that the colour of a body in white light depends upon the nature of the light waves which it reflects.
A brief discussion of transparent glazes and of water-colour paints as absorbers of various light waves.

—The colour of bodies in coloured light. (Three periods.)

An experiment to show that a body which appears white in sunlight assumes the colour of any part of the spectrum in which it is placed.
An experiment to show that a body having colour in white light reflects wave lengths of that colour and absorbs light of other wave lengths.

—The colour of bodies in artificial light. (Three periods.)

A discussion of the composition of artificial light as compared with sunlight.
The effect of lack of some light waves in artificial light on the colour of coloured bodies, for example, the colour of a red pigment under a mercury-vapour lamp, or of blue and violet pigments under the incandescent lamp; stage lighting for colour effects.

Water.

—Municipal water supply. (Fifteen periods.)

Recall the study of water as outlined in Grade IX.
A practical study of the supply, purification, and use of water in an urban municipality.

Sand filtration:

(a) Clarification: the effect upon the grains of sand in the bed of adding aluminium sulphate (filter alum); an experimental illustration of the clarification of a clay suspension (the explanation not to involve chemical formulae).
(b) Detention of bacteria: recall past reference to harmful bacteria.

Chlorination: an explanation of its purpose (not to involve chemical formulae).
A laboratory demonstration by the use of Petri dishes and

agar to show development of colonies of bacteria from samples of water taken from (1) source, (2) the tap.
An experiment to prepare a sample of chemically pure water by distillation.
An experimental comparison of tap water, rain water, and distilled water as regards (1) dissolved substances, (2) the action on soap solution.

An experimental study of the methods used to soften water (1) in the home, (2) in industry.
A discussion of the importance of softening water (1) for laundry purposes, (2) for the prevention of boiler scale, (3) for the dyeing of textiles.

Common salt.
(Six periods.)

A study of the properties of sodium chloride, such as colour, taste, solubility in hot and cold water.
Experiments to prepare (1) a saturated solution of common salt, (2) crystals by slow evaporation of this solution.
A brief outline of the methods used for the recovery of salt from commercial deposits.
A demonstration of the production of sodium hydroxide and chlorine by the electrolysis of salt brine.
A discussion of the uses of salt and of its products in industry. (This discussion should be amplified by an examination of the materials.)

Fuels.
(Eight periods.)

Coal:
A discussion of the formation and the sources of coal deposits.
An experimental study of the properties of anthracite coal, bituminous coal, and lignite with respect to appearance, hardness, and the effect of strongly heating a sample of each in a small covered crucible.
A brief discussion of the coal gas plant, or the by-product coke oven, with respect to the production of coke, coal gas ammonia, and other important by-products. (A diagram of the plant is not required.)
Petroleum oil products:
A discussion of the world locations of petroleum oil, and the methods and channels of distribution, with specific reference to the British Empire.
An experiment to illustrate the fractional distillation of a water-alcohol solution.
A brief discussion of the application of the principles of fractional distillation to petroleum refining.
A brief discussion of types, grades, and uses of petroleum products.
Fuel gases:
A comparison of artificial and natural gases with respect to sources and characteristics.

Iron and steel.
(Four periods.)

A discussion of the kinds and sources of iron ores.
A brief discussion of the composition, characteristics, and uses of cast iron, steel, and wrought iron.

GRADE XII
COMMERCIAL DEPARTMENTS

No course in Science for Grade XII has been prepared. Teachers will continue with the course they have been using, with such modifications as may be deemed necessary.

AGRICULTURAL DEPARTMENTS

The Science Course for Agricultural Departments will consist of the topics in Science presented for Agricultural Science of Grades XI and XII of the General Course.

ART AND HOME ECONOMICS DEPARTMENTS

No course in Science for these Departments has been prepared. Teachers will continue with the courses they have used in the past, with such modifications as may be necessary.